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SCIENTIFIC RESEARCH UNDER THE AUSPICES OF THE ROYAL SOCIETY[1]

By Sir WILLIAM BRAGG, O.M.

THE PRESIDENT OF THE ROYAL SOCIETY

THREE magnificent gifts have been made during the last few months for the furtherance of research in this country. In May it was announced that Lord Austin had placed a quarter of a million sterling at the disposal of the University of Cambridge to be devoted to the work of the Cavendish Laboratory. More recently still Lord Nuffield has presented to the University of Oxford a million and a quarter for post-graduate research in medical science. This afternoon the council of the Royal Society has accepted on behalf of the society a principal share in the responsibility for the administration of a sum of £200,000 bequeathed by the late Mr. H. B. Gordon Warren. The interest of this money is to be applied to the encouragement of research in metallurgy, engineering, physics and chemistry. The administering committee is to consist of eight members appointed by the society and two by the governors of Williams Deacon's Bank.

[1] From the Anniversary Address given at Burlington House on November 30.

These great gifts are naturally a source of deep satisfaction to the fellows of a society which was founded for the purpose of "improving natural knowledge." The givers are men who are or have been engaged in industry: which fact is itself a source of gratification. It is good to see that practical affairs are in accord with the realization of the vital importance of research.

Lord Nuffield's gift recognizes the value of research for the prevention and cure of disease. The obvious success which has already been attained in this way is sure ground for the expectation of further benefits commensurate with the magnitude of the new effort. Lord Austin's gift is for the promotion of investigations which are at the time devoted mainly to the abstruse problems of the atomic nucleus. The terms of Mr. Gordon Warren's bequest suggest a more immediate contact with industry.

Thus these benefactions differ widely in respect to their immediate purposes: but they all acknowledge the same principle, that the improvement of natural

knowledge is essential to the general welfare. As for our society, it is the basis of its charter and the reason for its existence.

The capital value of the funds administered by the society, if we include in them the Warren bequest, is approximately a million sterling. In this amount is also included the bequest of about £40,000 by the late Sir Joseph Petavel, to which reference is made in the report of the council. By far the greater part of the money has been received within the last twenty years. In 1828 Dr. Wollaston founded the donation fund, the first fund of which the income was to be devoted to research; the amount was about £3,400. By the beginning of this century there were several such funds, the combined income of which was £1,375. In 1912 the total income had risen to a little over £2,000 a year. Then in 1919 began a period of large donations. First came the Foulerton gift and the Foulerton bequest. The Messel bequest was received in 1921. The Yarrow and the Mond funds came in 1923, the medical research fund in 1924 and 1925. To these the Warren bequest has to be added. In all the society now directs the expenditure of about £31,000 a year on research. The direction makes a considerable demand upon the time and energies of fellows, and it is a pleasant duty to acknowledge their willing and able service on numerous committees.

The use to be made of these moneys is to a considerable extent limited by the terms of the respective trusts. Nevertheless, here is ample opportunity for a general policy at the discretion of the society. It is natural and right that special emphasis is laid upon general or fundamental research, so far as donors' wishes allow; and indeed the terms in which the donors have expressed themselves are favorable to research of that kind.

It is to be observed that many other bodies possess funds which are administered for similar purposes. In a list published by the Royal Commission for the Exhibition of 1851, the commission itself takes place as one of the oldest, and the Leverhulme Trust as one of the newest. The list includes such well-known names as the Carnegie Trust, the Helley Stewart Trust, the Beit Memorial Fellowship Trust and others. City companies are also to be found here. The improvement of natural knowledge follows also on the activities of many bodies that have specific applications in view. Each branch of the Defence Services maintains its own research laboratories; so do the Medical Research Council, the Department of Scientific and Industrial Research, the Agricultural Research Council, the Post Office, and so on.

Still more closely concerned with the direct applications of natural knowledge are the laboratories of the country's industries. Many of these are of great and established reputation. On the whole, the industrial laboratory is some way from being as frequent a factor in industry as it ought to be, but undoubted progress has been made in recent years.

This brief enumeration of some of the agencies making for the improvement of natural knowledge will serve as a reminder that the sum total of the work done in this direction is very large. It may fall far short of what is to be hoped for, but it forms an agency which begins to acquire a certain coherence, something which can be viewed as a whole and considered in respect to its character and its effects. It is beginning to find itself, like Kipling's ship.

An immediate and obvious effect is the increase in the volume of published results. The publications of scientific societies have doubled and trebled in size; and their treasurers are in many cases hard put to it to meet the consequent additional expense. Numerous industrial publications also contain records of special investigations. There is every reason for satisfaction with the increase in natural knowledge which has followed on the encouragement of research.

In certain respects at least the application of the knowledge acquired is also satisfactory, though judgment on that point will vary according to the position of the observer in a very large field. There are obvious improvements in the health and general well-being of the nation, in its industries, in the strength of its trade and in its powers of defence; and these are matters of primary importance. Though they may be no more than means to an end, they and the appropriate application of knowledge are a first consideration.

To such applications every kind of research may contribute; for even those who would have it that science must be followed without thought of its usefulness must admit that it has to be very pure science indeed which only meets with its application, as a straight line meets its parallel, at infinity. In general the encounter may be expected to come so soon that its effect has a present importance, and must be taken into account. The individual member of the society may keep his thoughts and his experiments within an isolated region, and so contribute what is due from him as a fellow. But the society as a whole must take the wider view and watch constantly the relations between scientific advance and the people who are affected by it. It accepts these responsibilities when it undertakes to administer the great sums that have been entrusted to it. In the early days of the society the fellows recognized duties in these respects, as the records of their "Transactions" show. Many of the founders occupied important positions in the state and their science bore directly on the needs of the nation. Throughout the three centuries of its existence, the same ideals have encouraged the activities of the society. At some times they have been less effective

than at others, but their general purpose has never been blurred. The whole of the work of the society is therefore an important part of a general effort to improve natural knowledge in the expectation of resultant benefit.

Another consequence of that effort deserves especial consideration. The increase of knowledge and its applications are, each in its own way, worth working for. At the same time there should follow, and does follow, an increase in the quality and quantity of men who can add to knowledge and use it; also, it may be hoped, an increase in the number of those who realize its effectiveness. This is an exceedingly important point. It might seem unnecessary to observe that the resources which a nation possesses are of no use unless there are the foresight and the skill which are needed to make use of them. Yet a nation as a whole might fail to act on a principle to which its individuals would give a ready assent. The principle has to be stated plainly, so that it may be widely understood. One of the greatest assets of a nation is the presence within it of men who are quick to apply the knowledge of the time to the needs of the time. There are many varieties of such men. There are the handicraftsmen, whose skilled fingers are guided by intelligence; their number is greatly increasing in this country, though the contrary is often asserted. There are those who can assemble and combine materials for a given purpose, and there are others who can seize upon the broad consequences of a new discovery and choose the right moment for setting the old to one side. History has shown many times how the fate of a nation may depend upon its capacity to use the knowledge and the materials at its disposal. One may be reluctant to draw examples from the catastrophe of the great war, but in its heated atmosphere developments came quickly to maturity. During its course engines and devices of all sorts came into being which, before the war began, had never been thought of seriously, if at all. Such were tanks, paravanes, sound ranging, wireless telephony, aeroplanes and a thousand contrivances in every section of the war on the ground, under the ground, on the sea, under the sea, in the air. Their invention and development would not have been possible if there had not been the men for the work. It was fortunate that the nation also possessed a body of young men—chemists, physicists, engineers, biologists—trained in the laboratories of universities, technical schools, polytechnics, and so on, and in industrial workshops who were able to understand and work with the new devices. I doubt if the value of those trained young men has ever been fully realized. If, unfortunately, another great war broke out, the devices of to-day would surely be modified or superseded during its course, and the process of development would begin all over again. Provided that the defence withstood the first shock, the men with knowledge of materials and skill in using them would be in demand as before.

Though war times may furnish the more obvious examples, the developments of peace follow the same road, at a slower pace. The major industries of this country have owed their advance in part to the national resources and to political relations, but largely also to the skill of the country's scientific and technological workers. The electrical trades depend largely on discoveries which she has made and has been quick to use. The same may be said of her metallurgical work, of her shipping industry, of her business in textiles, of the dye industry in which she has now taken a position which might have been hers from the beginning. The battle for the health and the nutrition of the nation depends for its success upon the same qualities. This becomes continuously more so as natural knowledge increases, and its technical use requires a more intelligent craftsmanship.

Many a similar instance might be drawn from past history. But the past differs from the present in this, that the knowledge then to be drawn upon was scantier and far less abstruse. It was related to the technical skill of the workshop rather than, as now, to the science of the laboratory. The agencies of change were such as the discovery of cast iron, the invention of printing, the design of the ocean-going chronometer, the eighteenth-century additions to the loom, and so on. To-day great matters turn upon the complicated physical science of the wireless valve or the intricacies of the internal combustion engine, or the highly skilled chemistry that brings assistance to medicine or the combination of physics and chemistry, biology and engineering involved in the preservation of food.

From this point of view the suggestion sometimes made that scientific workers might take a holiday looks more ridiculous than ever. No nation could afford such an intellectual disarmament in the face of the world; nor could the world itself in face of the evils that are to be overcome.

The position of the men, and especially of the younger men, who are encouraged by these financial aids to devote the most ingenious years of their life to scientific research must be considered by those to whom the ordering of their lives is due. Some of the most brilliant young men in the empire are selected for a specific purpose, which purpose they undoubtedly fulfil. Good work is done, and when it is finished a fine and most useful type of man is available for further service. In a great number of cases the satisfactory opportunity of further service presents itself. But it is not always so. It is possible to find a man living on income derived from one Research Trust after another until he ceases from age or other limitations to be eligible for further aid. His work may

have been excellent, and his competence as great as ever, but he finds that he must look in some new direction for his living. Academic businesses may be of no use to him, nor he to them. His occupation has led him up to a blind alley. I am told that there is a certain tendency for men who have been employed in industry as research workers to change over, where possible, to purely administrative work which is expected to be more lasting and in the end more remunerative. There is here a hint as to the true cause of the trouble. The blind alley should be a thoroughfare leading to occupations more suitable to the men and better fitted to get the best out of them. It is obvious what these occupations are. They are places of responsibility to which specialists in science are as yet but rarely admitted. There is an encouraging beginning, but it takes time to realize that the man who is in touch on one side with the growth of natural knowledge should be in close touch on the other side with the opportunities of its application. He should be an equal in the council chamber rather than a subordinate in the waiting-room. On the other hand, the scientific expert must himself help to take down the barricade that makes the alley blind. This requires that his education should be much more than sufficient to make him only a laboratory man: which brings us back again to the very important point that the man himself must be as much the care of those who give him research work to do, as is the work which they set before him. Obviously, the more complete the equipment of the man, the better the chance that he will make his way, and the wider his final influence. The bodies that administer research funds are already beginning to consult each other for the sake of better efficiency in the choice and direction of workers. As this becomes more general, there will surely be an effort to take a wider view of the responsibilities which the magnificent generosity of public men has placed upon them.

Reference is made in the report to a plan of research on malaria in India. I think that I may well amplify the reference by describing rather more fully the proposals of council in respect to Indian medical research, especially as it involves the adoption of a policy which it is to be hoped will commend itself to the society.

In 1924 the Royal Society received a legacy of £10,000, and in 1925 £28,108 19*s.* 6*d.*, being part of the residue of an estate, for the prosecution of original research in medicine, for the prevention of disease and relief of suffering, with special reference to tropical diseases in British possessions. There are particular reasons associated with the gift for connecting its use with India. The council decided at its meeting on July 9 that the whole income, together with the invested income, shall be employed for five years (i. until October 31, 1941) as follows:

A.—*Malaria research:* It decided to offer to Colo Sinton, I.M.S., a stipend for five years to enable to work at the Horton Centre on certain aspects malaria. The Horton Centre will be under the con of the London School of Hygiene and Tropical Me cine, and unique opportunities will be available th for clinical study, for observations on the mala parasite in man and *Anopheles,* for investigation the serology and immunology of malaria and chemo-therapeutic testing and experimentation on human subject. Colonel Sinton is now, and has be for many years, actively engaged in malaria work India.

B.—*Experimental studies on the ecology of cert species of Anopheles:* Where the control of mala is successful it is nearly always achieved by measu directed against *Anopheles.* A detailed plan has be suggested by the London School of Hygiene and Tro ical Medicine, by which a young man experienced modern experimental zoology should be given oppo tunity for twelve to eighteen months, at that scho to learn about mosquitoes in general and the orient species of *Anopheles* in particular, and should unde take experimental work in the physiology and b havior of *A. maculipennis.* He should then be se for two and one half to three years to an appropri center in India to carry out a program connecti malaria with the behavior of *Anopheles.* Council w informed that for the tropical portion of the sche part of the cost could probably be met by the Lond School of Hygiene and Tropical Medicine. Assu ing that this is the case, it decided that a sum up £3,750 be offered provisionally, over a period of fi years, to finance the project. A suitable investigat has been appointed in Mr. Muirhead Thomson.

C.—*Nutrition in India:* The existence of wid spread malnutrition in India is beyond dispute, b more detailed and intimate information is required to its incidence and effects. The council decided th Dr. C. Wilson should be offered a research grant f one year in the first instance, with possible extensi for two more years, to enable her to make a surv of the nutritional condition of Indian families and draw up a report. A study of the incidence of m nutrition among school-children, an investigation dietary habits, an assessment of the value of foods common use, etc., would be made in collaboration wi the Indian Research Funds Association and with D Aykroyd, its director of nutrition research. Dr. W son will be able, if necessary, to work for only pa of the year in India, returning to England to car out a statistical and experimental analysis of her r sults. One of her objects while in India will be

build up and train a small body of collaborators by which the work will be aided and perpetuated.

The total estimated cost of the three schemes, over a period of five years, is £8,550. The council of the Royal Society believes that by a far-reaching plan of this character, involving work of three different kinds, all bearing on health in India, its medical research fund can be better employed than by small grants made from time to time for worthy but minor purposes. It could make good use of far more substantial funds on analogous lines.

Reference is made in the report of the council to the decision in the matter of the postal ballot; this required the invocation of a curious provision contained in our ancient charters. We were directed, in cases of a difference which we could not settle ourselves —and in this instance our legal advisers had been unable to settle it for us—to call in the services of certain high officers of state. This we did, and the officers in question responded promptly, taking, I believe, no little interest in this ancient direction and its present application. We are greatly in their debt for their very kind assistance.

The great increase in the amount of material to be published has brought with it certain serious inconveniences. It has always been the practice of the Society to scrutinize with great care all papers submitted to it. Fellows have been ready to undertake this task, though, as we all know by experience, the labor involved is serious. Three times as many papers have now to be examined, as compared with a few years ago, and there has been no material increase in the number of those who are available as referees. It is not surprising that men who lead busy lives find it difficult to attend promptly to the work which they are asked to do, especially as the intricacies of modern science may make it necessary for a referee to devote days to any one paper. If there is much delay, there is disappointment at the tardy publication of matter which the writer naturally thinks ought to appear at once.

The council has considered this matter carefully and has come to the conclusion that in the great majority of cases the summary of a paper might be set up in type and distributed within a very few weeks of its receipt, without waiting for the verdict of the referees on the paper as a whole. A fellow who communicates a paper will, of course, take the responsibility for the summary. The reading of the paper and its publication in full will follow in due course, as the responsible committees advise, on receipt of the opinions of the referees.

Three years ago Sir Gowland Hopkins in his presidential address spoke with admiration of the work of the organic chemist and in particular of the "emergence of power to grasp the architecture of complex invisible entities such as organic molecules and the ability to construct them at will." He told how under modern methods of investigation the picture which the chemist had formed of the invisible molecule had actually taken shape. His picture-making had been amply justified. His stereometry was not, as some thinkers had maintained, to be swept away in favor of a mathematical symbolism. On the contrary, its usefulness would surely grow as the new methods were developed.

This anticipation has been fully realized during the last few years, mainly through the remarkable increase in the accuracy with which the structure of molecules, molecular aggregates and solid bodies in general can be determined. For this the methods of x-ray analysis of crystalline structure have been largely responsible. Moreover, other methods have been greatly strengthened by the example set by x-ray analysis and by its reactions upon themselves. Optical, electrical, magnetic and other properties have been successfully studied with the same great purpose, *viz.*, the correlation between the properties of a substance and the spatial arrangements of its components.

While the x-ray methods have been mainly useful in describing the arrangement of the atoms in assemblages surrounded by others of like nature and conditions, the methods of electron-diffraction are giving a remarkable insight into the modifications of arrangement that are to be found on surfaces. The extraordinary interest of such knowledge arises from the fact that natural processes so largely depend on surface actions.

For many years after its inception the x-ray analysis was, as might be expected, engaged in trying its own powers and learning how to apply them. It cleared up many structural problems on which older methods had little to say that was definite, as for example the distinction between ionic, metallic, adamantine and molecular compounds. Many crystalline structures were determined, and the results, as is well known, have been serviceable in a wide field of scientific research, and in many industrial processes. The methods of analysis, the technique and the interpretation of results have been greatly improved, as might be expected, by the researches of many hundreds of workers. The increase in accuracy is so great that new possibilities of usefulness come into view.

The improvement appears in two ways. In the first of the two, the measurements of the dimensions of the unit of pattern of a structure can now be made to one part in several thousand. Consequently, the determination of the electron charge *e*, made by the x-ray method, can stand beside the older determinations of the oil-drop method. There is a persistent discrepancy of about one part in two hundred, the former giving

the value 4.80×10^{-10}, the latter 4.77×10^{-10}; but it is clear that the larger value is at least as near the true value as the smaller. A full discussion of the x-ray method is given by Compton and Allison in their recent book on "X-rays," and a critical examination of some outstanding points is made by du Mond and Bollman.[2]

Again, as has been observed by Bernal, the use of high-precision determinations of the lattice constants of metals will soon become the most reliable gauge of purity of a metallic element. Accuracy has here been pushed to one or two parts in forty thousand. Again, the phase boundaries of an alloy can be very closely and conveniently defined by observations of such a character. Accuracy has been of great importance to the well-known work of Hume Rothery on alloy structures, and to the curious and very important relations between order and disorder in alloys which have been specially studied at Manchester.

The accuracy with which the position of each atom in the unit cell can be measured is of quite a different order. Thanks in particular to the use of Fourier analyses by J. M. Robertson and others, the distances separating the atoms, center to center, can be found to about 1 per cent., even when the complicated molecules of organic crystals are under examination. This is a great advance on the possibilities of even a few years ago, and it has important consequences. In particular, fresh light is thrown upon the problem of the chemical bond. At one time, single, double and triple bonds were considered to be distinct and definite phenomena. The tetravalency of carbon, for example, was described as an assemblage of four equal powers of combination, of which one or more might be exercised in the same direction. When the diamond structure was found by the x-ray methods, it was no matter of surprise that the four separate single bonds were displayed in the attachment of each carbon to four neighbors. In the structure assigned by the chemist to benzene, the fact that each atom had but three neighbors presented difficulties; various theories have been suggested in explanation, mostly little more than different ways of drawing diagrams, in which four single bonds were made to act somehow. In recent years, it has been more usual to propose that bonds may alternate between single and double, and that the tetravalency of carbon in the benzene ring is satisfied because three of the six links are double and three single, the two kinds alternating both in time and in order round the ring. The conception can be extended to cases much more complicated, provided that the two forms between which alternation occurs do not differ much either in form or energy. The effect is described as one of "resonance," a term due to Hund but applied to organic chemistry mainly by Pauling and his collaborators. Its bearing on structural chemistry was discussed by Sidgwick a few months ago in a presidential address to the Chemical Society.

When substances in which this "resonance" is supposed to occur are examined by the x-rays, it is found that the actual center to center distance of two atoms connected by alternating a link between single and double is characteristic of neither of the two extremes. These last two are definite quantities, and the length of the varying link lies between them. An actual link is rarely a pure single or double or triple link. Pauling and Sidgwick both discuss a number of cases in which the center to center distances can be correlated with a probable or possible amount of resonance. An excellent example is furnished by oxalic acid, which was examined by Zachariasen in 1934, but has just been remeasured by Robertson, using the powerful Fourier method of analyzing the observations. The distance between the carbon atoms is 1.43 A. The length of the single link of diamond is 1.54 A. The length of a double bond is very nearly 1.33 A. It might seem that in oxalic acid the link is actually more nearly double than single; but this is not so. A small proportion of double linking seems to shorten the distance considerably. For instance, each link in the hexagonal network of graphite must be two thirds single and one third double, yet its length is 1.41 A. In benzene, the half and half arrangement (following Kékulé) is correlated with a length of 1.39 or 1.40 A. Thus the actual length of a bond may prove to be a safe indication of its nature. Robertson points out that the oxalic acid molecule is always planar, which may be accounted for on the ground that rotation is restricted round a link which is even partially of double character.

It has recently been shown by Bernal and Megaw that in all probability there are two types of bond linking oxygen atoms through intermediary hydrogen. The one is the "hydrogen bond"; it is found, for example, in acids, and it corresponds to a separation distance, oxygen to oxygen, of 2.55 A. The other is the hydroxyl bond; it is found in a number of hydroxides, and its length is about 2.8 A. By the use of this conception it has been found possible to locate the positions of the hydrogen atoms in several hydroxide structures, particularly in the clayey mineral hydrargillite. The oxalic structure of Robertson seems to supply a new and interesting example of the difference between the two kinds of bond. One of the oxygens at each end of the oxalic acid molecule is bound to a water molecule in the crystal by a link 2.87 A, the other by a link 2.52 A.

[2] *Phys. Rev.*, September, 1936.

[3] *Proc. Roy. Soc.*, A, vol. 151, p. 384, 1935.

It has been pointed out[4] that the linking up of hydroxyl bonds explains the properties of the gels that are formed by neutral hydroxides.

These few examples may serve to show how improvements in the technique of x-ray analysis are sharpening a tool which has already been of assistance to research in many directions and now seems to be acquiring a new usefulness.

The chemist has already shown that the properties of the molecule depend on the internal disposition of its atoms. The characteristics of the solid state depend also on spatial relations, and in a manner which is even more complicated, much more complicated than in the case of the independent molecule. Accurate measurement of the spatial arrangements lays a firm foundation for the study of the properties of a substance in relation to its structure and its composition. The problems to be solved are, of course, extremely complex, but it is surprising how much can be done towards the examination of intricate molecular associations when the spatial relations between the most commonly occurring atoms are known. This applies, for example, to the study of the proteins which has already gone far; to the clays, and to the glasses and other extended structures. At one time it seemed hopeless to expect to learn much of the structure of bodies which were so irregular as to give no sign of crystallinity. But it is now possible to work from the regularity in occurrence of a few definite separation distances, even when regularity in orientation does not exist: and methods have been devised by which these distances can be determined by the x-ray methods.

It is clear, I think, that the stereometry which the chemist has developed so successfully is acquiring new powers which will have the widest applications.

SCIENTIFIC EVENTS

GERMANY AND THE NOBEL PRIZES

FOLLOWING the award of the Nobel Peace Prize to Carl von Ossietzky, the German pacifist who was confined at the time in a concentration camp, Chancellor Adolf Hitler issued on January 30 a decree which reads:

> In order to avert such shameful occurrences for all future time, I decree with this day the foundation of a German national prize for art and science.
>
> This national prize shall be divided annually among three worthy Germans to the amount of 100,000 marks each.
>
> Acceptance of a Nobel Prize is herewith forbidden to all Germans for all future time.
>
> Executive orders will be issued by the Reich Minister for Popular Enlightenment and Propaganda.

At the Propaganda Ministry it was emphasized that the prohibition applied not merely to the peace prize, but to all Nobel awards.

The New York Times prints in full the statement made to the Reichstag by its president, Colonel General Hermann Goering, which reads:

> Ridiculous insults which proceed partly from rage and partly from the bad taste of others can neither offend nor shame Germany. They merely fall back on those from whom they come, and especially on those who always pride themselves on their special good breeding.
>
> When we see attempts to insult Germany before the world by awarding a peace prize to a traitor, to a person punished with penal servitude, then such action does not shame Germany but merely makes those ridiculous who are responsible for it.
>
> But because Germany will not tolerate such shameful things in the future and does not want any dispute about them at all, the Fuehrer has created this day a national prize for art and science.
>
> May the world realize from this that everything which it may undertake to insult the German people will always fall back on the other. It is, as the Fuehrer has repeatedly emphasized, a singular characteristic of present-day democracies to ignore facts and realities. But one must learn in time that the once torn and impotent Germany has been transformed into a proud, strong, honest, honor-loving, freedom-loving people—a people that has a right to be proud of its achievements before all nations, before history, before the future.

An Associated Press dispatch from Stockholm of the same date reports that Germany's ban on acceptance of Nobel Prizes by Germans will have no effect on the granting of awards by the Nobel committee. Professor Karl Manne Siegbahn, a committee member who won the prize for physics for 1924, asserted that the awards would be without regard for German laws, on the ground that no distinctions were possible between German and other scientists. However, whether payment is possible is a matter between the winner and his government.

A JOURNAL OF "PARAPSYCHOLOGY"

DUKE UNIVERSITY News Service has sent to SCIENCE the following release:

> Establishment of a new scientific journal devoted to research in telepathy and clairvoyance has been announced by the Duke University Press. The journal will be called the *Journal of Parapsychology* and will be edited by Professor William McDougall and Dr. J. B. Rhine, with the assistance of Charles E. Stuart. It will be issued quarterly.

[4] Fricke, *Koll. Z.*, vol. 69, p. 312, 1934.

The rapid growth of the Duke experiments, and especially the development of similar work in other institutions of learning and elsewhere, has made it necessary to publish the journal to provide a proper outlet for articles in the field of study. The extraordinarily widespread public interest in this work, it is felt, justifies the founding of a magazine devoted entirely to these topics.

Parapsychology is a branch of psychology which includes such subjects as telepathy and clairvoyance and whatever other unusual capacities of mind may be discovered that do not fit into the recognized order of things. Although articles in the new Duke journal will be written in the usual scientific manner, they will not be unintelligible to the average educated person. The journal will have the special feature of presenting editorial abstracts of the articles to give the gist of each in non-technical terms.

The new journal is the first and only academic scientific journal devoted to the field of parapsychology. Though it is published at Duke, its columns are to be shared with other institutions where members are engaged in similar research.

Professor McDougall, eminent psychologist at Duke University, is a veteran in the field of parapsychology. He was formerly president of the English Society for Psychical Research and of other well-known organizations. He has been on scientific investigating committees and is considered the leading psychologist who has given his attention to the parapsychological branch.

Dr. Rhine has been in active charge of the experimental studies of clairvoyance and telepathy, or extra-sensory perception, as they are called, and has opened up through his book, ''Extra-Sensory Perception,'' a new interest in these subjects and a new experimental attack that is world wide. Mr. Stuart is Prince memorial fellow at the Duke parapsychological laboratory and is the author of several articles on the subject.

THE FIRE IN LYMAN HALL OF NATURAL HISTORY, SYRACUSE UNIVERSITY

THE following is a brief report on the serious fire in Lyman Hall of Natural History at Syracuse University on January 11.

Smoke issuing from the roof of the southeast wing at about 1:20 P. M. was the first observed indication of the fire on the outside of the building; and smoke from the ceiling and walls of one of the rooms on the fourth floor was the first indication that those within the building had of the fire. It apparently did not arise in either of the laboratories or the museum.

The damage to the Natural History Museum is serious, as many of the exhibits are irreplaceable. The main losses in the museum were reported in SCIENCE, January 22.

Professor Ernest Reed, chairman of the department of botany, had his laboratory for genetics, mycology and plant pathology on the fourth floor. All the illustrative material for the course in genetics, mycology and plant pathology has been lost. The large research collection of cultures of Fusarium and other fungi which Professor Reed and his graduate students have collected during the past fifteen years was destroyed. Professor Reed has also lost notes and materials of his twenty years of study of inheritance in the sugar beet. At the present time he is on a collecting trip in Colombia and Venezuela and it has not been possible to get word to him of the destruction of his laboratory.

Professor Parke Struthers, of the department of zoology, was also located on the fourth floor. He was in charge of the courses in comparative anatomy and vertebrate zoology. The collections and equipment in these fields accumulated during the past thirty years is almost a total loss. Professor Struthers's chief losses are his collection of separates, his embryological material on the porcupine and numerous collections of skeletons.

The fire losses were limited to the fourth floor, but the water damage extends to the basement. A roof is being put on, and it is expected that classes will be able to return to the building by February 15 to use the three floors and the basement.

The university is protected by insurance. Professors Reed and Struthers will have to build entirely their research material.

I am wondering whether those interested in genetics, mycology and plant pathology may not have extra separates that they would be willing to contribute to the department of botany; or those in comparative anatomy and vertebrate zoology, separates that they would give to the department of zoology. Any such gifts will be appreciated and should be mailed to the Main Library, Syracuse University, and marked "For the Department of Botany" or "For the Department of Zoology."

W. M. SMALLWOOD

THE AMERICAN PHILOSOPHICAL SOCIETY CONFERENCE ON THE RESPONSIBILITY OF ENDOWMENTS

THE American Philosophical Society is sponsoring a joint meeting with representatives of foundations, societies and institutions administering funds in aid of research, to be held on February 19 and 20, in the hall of the society at Independence Square, Philadelphia.

On Friday, February 19, closed sessions, including round-table conferences, will be held from 10 A. M. to 1 P. M. and from 2 to 5 P. M., presided over by Dr. Edwin G. Conklin, vice-president of the society. Waldo G. Leland, permanent secretary of the American Council of Learned Societies, will open the discussion of some or all of the following subjects:

1. Grants-in-aid as distinguished from fellowships and scholarships.

2. Relative emphasis on projects and men.

3. To what extent should administration endeavor to seek out promising projects and men?

4. How best may reliable information be secured as to the merits of projects and the competence of applicants?

5. For what specific purposes should grants be made? *e.g.*, salary of applicant; travel and maintenance; assistance, technical and clerical; exhaustible supplies; equipment of lasting value, *e.g.*—apparatus, books, MSS, etc., and their ultimate disposal.

6. Desirable size limits of grants-in-aid. Should they be generous or limited to necessities?

7. Under what circumstances should grants be renewed, and should renewal be so frequent as to constitute continuous assistance?

8. What oversight or control should be exercised over the use of grants, the expenditure of money, the progress of research?

9. What have proved to be the most effective administrative devices for bringing systems of grants-in-aid to the attention of scholars, for handling applications, for assuring careful study of applications by experts and committees, and for making awards?

10. Is it desirable to promote large projects by relatively small grants from many sources?

11. Are prizes, whether competitive or honorary, an important means of promoting research?

12. Is it desirable to effect a better coordination among the various agencies that offer grants-in-aid, either as to the size of grants, the fields in which they are offered, or the overlapping of applications? What has been their distribution among fields of study and among grades of scholars?

Luncheon for members and invited guests will be served at 1 o'clock. At an open session on Friday evening at 8:15, Dr. Frederick P. Keppel, president of the Carnegie Corporation, New York, will speak on "The Responsibility of Endowments in the Promotion of Knowledge."

On Saturday morning an open session will be held at 10 o'clock on "The Most Important Methods of Promoting Research," as viewed by representatives of

1. Research Foundations and Institutions.
2. Learned Societies, Academies and Councils.
3. Universities, Professional and Technical Schools.
4. Research Workers and Recipient Institutions.

Roland S. Morris, president of the society, will preside over this session, and Dr. John C. Merriam, president of the Carnegie Institution of Washington, will make the opening address. A luncheon for members and invited guests has been arranged for 1 o'clock.

THE TWENTY-FIFTH ANNIVERSARY OF THE JOHNS HOPKINS SCHOOL OF ENGINEERING

The Johns Hopkins School of Engineering will celebrate its twenty-fifth anniversary with a series of events beginning on Friday evening, February 19, with a diversified modern engineering exhibit. An address by Dr. Karl T. Compton, president of the Massachusetts Institute of Technology, will be given on the morning of the twenty-second at the sixty-first commemoration day exercises of the university. On this occasion honorary degrees will be awarded to several distinguished engineers.

On the morning of the twentieth, alumni, officials of the city and state and faculty members from other colleges will hear and discuss papers read by senior professors of the School of Engineering. These discussions will center about current research projects in which the members of the faculty have been actively engaged and concerning which numerous publications have appeared. The subjects will include high voltage insulation, electrical accidents, power development, water purification, gas engineering research and scientific motor vehicle taxation.

At four o'clock, on February 22, Professor Niels Bohr, director of the Institute for Theoretical Physics at the University of Copenhagen, will speak on "The Problem of Causality in Atomic Theory." Professor Bohr, who was awarded the Nobel Prize in 1922, will be a guest of the winner of the prize in 1925, Professor James Franck, now professor at the Johns Hopkins University. The lecture will be in the A. R. L. Dohme series. The concluding event of the program will be the alumni dinner at 6:30 in the evening. Abel Wolman, a member of the first graduating class, now the chief engineer of the Maryland State Department of Health, will be the principal speaker. His topic will be "The Engineer and Society."

Portions of the public exhibit will be devoted to the main branches of research and industrial engineering. Laboratory technique and facilities as well as instruction methods may be observed by visitors to the show. Many commercial appliances and processes will be brought in for the duration of the anniversary events and students will operate equipment and models reflecting recent discoveries. Several methods and pieces of apparatus developed at the Homewood laboratories will be demonstrated.

Early in the university's history President Daniel C. Gilman indicated his hope that the development of facilities at Johns Hopkins would witness the establishment of a school of engineering. That hope was realized in 1912 when the present dean of the school, Professor J. B. Whitehead, joined with Dr. Carl Clapp Thomas and Dr. Charles J. Tilden to form the department heads of the first faculty. On its twenty-fifth anniversary the school has three departments of civil, electrical and mechanical engineering accredited by the

Engineering Council for Professional Development. A department of chemical engineering has been recently established.

N. S. H.

RECENT DEATHS

LAWRENCE BRUNER, since 1895 professor of entomology at the University of Nebraska, died on January 30 at the age of eighty years.

JOHN H. GREGORY, since 1921 professor of civil and sanitary engineering at the Johns Hopkins University, died on January 18 at the age of sixty-two years.

JOHN ALEXANDER MACWILLIAM, until his retirement in 1927 with the title emeritus professor of physiology at the University of Aberdeen, died on January 13 at the age of seventy-nine years.

THE death is announced at the age of sixty-eight years of Percy Andrew Ellis Richards, for over twenty years professor of chemistry at Queen's College, London, and lecturer in chemistry and metallurgy at the Royal Dental Hospital.

THOMAS CROOK, since 1928 principal of the Mineral Resources Department of the Imperial Institute, London, died on January 6.

ORSO MARIO CORBINO, formerly professor of experimental physics at the University of Messina and later at the University of Rome, died on January 23 at the age of sixty years. In 1920 he was appointed a senator and in 1921 became Minister of Education in Premier Bonomi's cabinet. After the rise to power of Mussolini, he served for two years, 1923 and 1924, as Minister of National Economy.

SCIENTIFIC NOTES AND NEWS

AT the Founders' Day celebration of the University of Wisconsin on February 6, which commemorated the eighty-seventh anniversary of the opening of the first class of the university, special honor was paid to Dr. Edward Asahel Birge, president emeritus of the university, who is now eighty-five years old. Hundreds of alumni took part in the celebration by attending dinner meetings which were held in all parts of the country. At Madison a testimonial was presented to Dr. Birge by the alumni association in recognition of his long service to the university and the state. Dr. Birge went to the state university in 1875 as an instructor in natural history. He was professor of zoology from 1879 to 1911, and served as dean of the College of Letters and Science from 1891 to 1918. He was acting president of the university from 1900 to 1903, and in 1918, following the death of President Charles R. Van Hise, he was elected president. He served until 1925, when he retired as president emeritus.

THE council of the Geological Society, London, has awarded the Wollaston Medal to Professor Waldemar Lindgren, of the Massachusetts Institute of Technology, for his researches concerning the mineral structure of the earth, and especially concerning the problems of mesasomatism, contact ore-deposits and the application of physical chemistry to ore-deposition.

AN award for distinguished service to agriculture was made to Maurice Adin Blake, professor of agriculture at Rutgers University, at the opening session of the State Agricultural Convention in the Assembly Chamber at the Capitol on January 26. Professor Blake has developed some 100 new varieties of peaches.

THE Bulgarian Order of Civil Merits with Golden Crown has been conferred by King Boris III on Dr. J. C. Th. Uphof, of Orlando, Fla., in recognition of his researches in botany. These have been published in the English, French, German, Dutch and Spanish languages.

THE British Royal Astronomical Society has awarded its Gold Medal to Dr. Harold Jeffreys, university reader in geophysics at the University of Cambridge, for his researches into the physics of the earth and other planets and for his contributions to the study of the origin and age of the solar system.

DR. VILHJALMUR STEFANSSON was elected president of the Explorers' Club, New York City, at a meeting held on February 3. Dr. Walter Granger, whom Dr. Stefansson succeeds as president, was elected *first vice-president;* Lowell Thomas was named *second vice-president;* H. R. Forbes, *third vice-president;* H. E. Winship, *treasurer,* and Joseph Robinson, *secretary.*

DR. ROGER W. TRUESDAIL, of the Truesdail Laboratories, Los Angeles, has been elected president of the Sigma Xi Club of Southern California, and J. A. Hartley, president of the Braun Corporation, Los Angeles, has been elected secretary-treasurer.

AT the thirty-ninth annual meeting of the Washington Academy of Sciences, held on January 21, the following officers were announced for 1937: *President,* Charles Thom, Bureau of Plant Industry; *Corresponding secretary,* Nathan R. Smith, Bureau of Plant Industry; *Recording secretary,* Oscar S. Adams, Coast and Geodetic Survey; *Treasurer,* Henry G. Avers, Coast and Geodetic Survey; to the *Board of Managers* for three years, F. G. Brickwedde, National Bureau of Standards, and J. F. Couch, Bureau of Animal Industry; *Non-resident vice-presidents,* Thomas Barbour, Cambridge, Mass., and P. W. Bridgman, Cambridge,

Mass. Vice-presidents nominated by the affiliated societies were elected as follows: Philosophical, Frank Wenner; Anthropological, F. H. H. Roberts, Jr.; Biological, H. C. Fuller; Chemical, J. H. Hibben; Entomological, C. F. W. Muesebeck; Geological, W. T. Schaller; Medical, H. C. Macatee; Historical, Allen C. Clark; Botanical, John A. Stevenson; Archeological, Aleš Hrdlička; Foresters, S. B. Detwiler; Washington Engineers, Paul C. Whitney; Electrical Engineers, H. L. Curtis; Mechanical Engineers, H. L. Whittemore; Helminthological, Emmett W. Price; Bacteriological, H. W. Schoening; Military Engineers, C. H. Birdseye; Radio Engineers, J. H. Dellinger.

Dr. Wilson G. Smillie, professor of public health administration in the School of Public Health at Harvard University, has been appointed professor of public health and preventive medicine and head of that department in the Cornell University Medical College, New York City. He will represent Cornell University in the supervision of the health center in Kipps Bay, Yorkville, now being erected in cooperation with the Department of Health of New York.

Dr. George H. Godfrey, of the Pineapple Canners' Experiment Station at the University of Hawaii, has joined the staff of the Division of Entomology and Parasitology of the University of California at Berkeley.

At the Massachusetts State College, Dr. C. E. Gordon, in charge of entomology, zoology and geology since 1930, has, at his request, been relieved of the direction of the work in entomology. The trustees of the college have voted to reestablish the department of entomology.

Dr. William Christine Anderson will retire as dean of the Brooklyn College of Pharmacy on September 1 and will become dean emeritus.

Clifford C. Gregg has been appointed acting director of the Field Museum of Natural History, Chicago, to take the place of the late Stephen C. Simms, who had been chief executive of the museum since 1928. Mr. Gregg has been a member of the staff since 1926, and has served as assistant to the director under both Mr. Simms and the preceding director, the late David C. Davies.

Dr. Waldo R. Wedel has been appointed assistant curator in the Division of Archeology of the U. S. National Museum.

Nandor Porges has been appointed assistant bacteriologist at the By-Products Laboratory of the Farm Wastes Investigation Division of the Bureau of Chemistry and Soils of the U. S. Department of Agriculture. He is stationed at Ames, Iowa.

Dr. Arthur Paul Jacot has been appointed a member of the Northeastern Forest Experiment Station, New Haven, Conn., where he will continue his work on the ecology of the fauna of litter and soil.

Dr. Berwind P. Kaufmann, professor of botany at the University of Alabama, is on leave of absence for the second semester and will be a visiting investigator at the department of genetics of the Carnegie Institution of Washington at Cold Spring Harbor, Long Island, until September.

Dr. Max Cutler, of the Medical School of Northwestern University, has a leave of absence, during which he will serve as visiting professor in surgery in the Peiping Union Medical College. He will conduct a tumor clinic under the auspices of the Rockefeller Foundation.

The Committee on Scientific Research of the American Medical Association has made the following grants: Alexander S. Wiener, Jewish Hospital of Brooklyn, agglutinogens in human blood; Irving Graef, New York University, pulmonary reactions to instillation of lipids and mineral oils; Moore A. Mills, Northwestern University Medical School, experimental pulmonary tuberculosis in the dog; M. M. Wintrobe, Johns Hopkins University, red corpuscles; Edward S. West and G. E. Burget, diuretic action and chemical metabolism of sorbitol; S. J. Crowe, the Johns Hopkins University, physiology of hearing; Ernest Carroll Faust, Tulane University, epidemiology of trichinosis in New Orleans; George Herrmann, University of Texas, heart muscle chemistry; Paul M. Levin, the Johns Hopkins University, cerebral efferent tracts in primates.

Dr. J. D. Cockcroft will give a series of six lectures on the work on "Nuclear Physics and Low Temperature Research," carried out in the Cavendish Laboratory at the University of Cambridge, in the Jefferson Physical Laboratory, Harvard University, beginning on the afternoon of March 25 and continuing through the following week. Physicists who are able to attend these lectures will be welcome.

Dr. Thorvald Madsen, director of the Serum Institute, Copenhagen, will deliver the fifth Harvey Society lecture of the current series at the New York Academy of Medicine on February 18. Dr. Madsen will speak on "The Scientific Work of the Health Organizations of the League of Nations."

Dr. T. Wingate Todd, Henry Willson Payne professor of anatomy at Western Reserve University, will deliver the thirteenth Lewis Linn McArthur lecture of the Frank Billings Foundation before the Institute of Medicine of Chicago on Friday evening, February 26.

His subject will be "Objective Ratings on the Constitution, Based upon Examinations of Physical Development and Mental Expansion in the Growing Child."

DR. ALFRED C. LANE, professor emeritus of geology at Tufts College, lectured before the Society of Sigma Xi at the Ohio State University on January 7 on "Measurement of Geologic Time." Dr. Lane also spoke before the department of geology of the university on the afternoons of January 6 and 7 on "Radioactive Methods Applied to Pre-Cambrian Classification" and "Principles of Economic Geology."

PROFESSOR S. LEFSCHETZ, of Princeton University, gave recently a lecture in the Dohme series at the Johns Hopkins University on "What is Topology?" He also spoke before the Mathematics Club of the university on "Some Applications of Algebra to Topology."

PROFESSOR EDWARD KASNER, of Columbia University, gave two lectures in January at the University of South Carolina on "Infinity" and "Geometric Transformations."

DR. LEWIS W. HACKETT, assistant director of the International Health Division of the Rockefeller Foundation and representative of the foundation in Italy and Albania, is giving on Tuesdays and Fridays from February 2 to February 19 a series of six Lowell lectures entitled "Man against Malaria in Southern Europe."

THE Sigma Xi Chapter at the University of Rochester will hold its annual science exhibit on February 22. Dr. George Packer Berry, professor of bacteriology and associate professor of medicine in the School of Medicine and Dentistry, will speak to an audience of school children on "Viruses and Their Influence on Public Health." Dr. H. S. Gasser, director of the Rockefeller Institute for Medical Research, will deliver the evening address.

THE fourth annual meeting of the American Institute of Nutrition will be held in Memphis, Tenn., on April 21. Hotel headquarters will be at the Hotel Peabody. Officers for 1936–37 are: *President,* Dr. Eugene F. DuBois; *Vice-president,* Dr. Mary Swartz Rose; *Treasurer,* Dr. George R. Cowgill; *Secretary,* Dr. Icie G. Macy; *Members of the Council,* Drs. C. A. Elvehjem, R. M. Bethke and L. A. Maynard. There will be a luncheon and dinner at the hotel. The program will consist of approximately twenty scientific papers and the evening program will consist of six or eight discussion groups.

Nature reports that at the invitation of the Royal Society, the International Council of Scientific Unions will hold its triennial General Assembly at Burlington House, London, from April 27 to May 4. China, through the Academica Sinica of Nanking, has recently joined the council, which now includes forty-two countries in addition to the International Unions of Astronomy, Geodesy and Geophysics, Chemistry, Scientific Radio, Physics, Geography and the Biological Sciences.

THE Executive Committee of the International Union of Biological Sciences has decided to postpone the general assembly of the union from July, 1937, until the year 1940. The next assembly will be held at Stockholm immediately before the seventh International Botanical Congress, probably from July 11 to 20.

THE annual summer term of the American School of Prehistoric Research will open in Paris on July 1, 1937. The tentative program includes lectures, museum studies, practice in excavating and excursions in various parts of France, including the valleys of the Oise, Seine and Somme, the Dordogne region, the Pyrénées, etc. Excavations will be carried on at the important stations of La Quina (Charente) and Mas d'Azil (Ariège). The Abbé H. Breuil, foremost authority on old world prehistory, will be in charge of the course and will be assisted by Harper Kelley, associate director of the summer term, which will last for at least six weeks. Prospective students should apply for enrolment as soon as possible. Applications for enrolment and for further information should be addressed to: George Grant MacCurdy, director, American School of Prehistoric Research, Old Lyme, Conn.

THE Geological Society of America has recently authorized a grant assuring the publication of the seventh edition of the James D. Dana "System of Mineralogy," first published in 1877. This task of revision is expected to consume the time of two competent specialists for approximately four years. It is then to be published by John Wiley and Sons, New York, publishers of the original volume, and will take the place of the volume prepared under the direct supervision of the late Edward S. Dana, and published in 1892. The present work is being carried forward by Drs. M. A. Peacock and Harry Berman in the laboratories of Harvard University, under the supervision of Professor Charles Palache, of Harvard University, and Professor W. E. Ford, of Yale University.

BY the will of the late Miss Mary Lee Ware, of Boston, who made possible the glass flower collection at Harvard University as a memorial to her father, the sum of $300,000 is bequeathed to the university. The president and fellows of Harvard College are directed to divide the income from the $300,000—one

third going to the support of Rudolph Blaschka and Mrs. Blaschka, whose family made the glass flowers and models; one third to preserve the collection; and one third to pay the salary of officials of the museum in which the objects are housed. The will expresses the wish that the director shall give prominence in the museum to the educational and practical side, and shall endeavor to augment the usefulness of the museum of exploration and investigation. The wish is also expressed that the director have discretionary power under the president and fellows as to expenditures necessary. Other bequests include $40,000 to the Boston Lying-In Hospital; $20,000 to Harvard University for the work of the Cancer Commission; $40,000 to the Boston Athenaeum; $20,000 to the Massachusetts Society for Mental Hygiene; $10,000 to Berea College, Kentucky; $20,000 to the Massachusetts Eye and Ear Infirmary; $70,000 to the Boston Museum of Fine Arts, and $30,000 to Harvard College for the Fogg Museum of Art.

THE *Fondation Scientifique de Lyon et du Sud-Est* is offering a fellowship of 10,000 francs for a period of nine months to a graduate student of chemistry, preferably of industrial chemistry. A fellowship of 18,000 francs for nine months and free transportation in the Tourist Class of the French Line is being offered through the *Office National des Universités et Ecoles Françaises* to an advanced graduate student who has specialized in science, preferably one who has obtained a doctorate in mathematics, physical science, chemistry or biology.

DISCUSSION

HYDROPONICS—CROP PRODUCTION IN LIQUID CULTURE MEDIA

IN the late summer of 1935 a number of large growers of certain vegetables and flowers adopted liquid culture media on a large scale for the growing of crops and have (for two seasons) placed on the market products so grown to compete with those produced by agriculture. Thus further evidence has been established that production of certain crops without soil is practicable and it appears that the introduction into the economic field of a new method of production, essentially another origin of agricultural crops, may well be considered as the birth of a new art and perchance a new science which should be designated by a distinctive name. The first announcement of the probability of the economic feasibility of liquid culture media for production of some agricultural crops was in 1929—"Aquiculture a Means of Crop-Production."[1] This announcement was made about two years after the investigations were started to establish the basis for the use of liquid culture media for the commercial growing of crops. Liquid culture media had been extensively used for nearly three quarters of a century for the growing of plants for study, but until the above reference no mention is found in the literature of investigations designed to apply the principle of water culture in a practical way to grow crops without soil. It was of course evident at the outset of the investigations that cultural techniques had to be designed to establish the physiological basis for the method within the framework of economic feasibility. The physiological basis is the markedly greater productive potentiality of certain crops grown on a per unit area of specially prepared nutrient water surface than that of a similar area soil. It is the manyfold larger production of some crops per unit area of water surface than that of soil which makes water culture economically feasible. A different point of view was required for the organization of the investigations leading to establishment of a method of crop production without soil, than that which prevailed in classical plant physiology using nutrient solutions for growing plants as material for experimental study.

As it is the purpose of this paper to give a name to this new method of production, no discussion will be entered into concerning the physiological basis on which it is founded. In other papers, consideration will be given to this and also to the economic and to the sociological features arising out of the development. However, a brief statement of the historic aspects of water culture experimentation appears in order in considering a name.

While it had been known before modern science took form that certain plants would develop roots and make some growth in water, nevertheless water culture proper dates from those experiments in which the elements found in plants and known to be derived from the soil were added to water to make a nutrient solution. The credit for such experiments is generally accorded to Knop, whose first paper in Landwirtschaftlichen Versuchsstation appeared in 1859. Other names would be mentioned in a complete treatise on the origin and development of water culture experimentation, and cognizance given to the spirit of the day, the methods of the time and the view-point of agricultural chemists and plant physiologists for their part in the development. Knop, an agricultural chemist, conceived water culture as a means of elucidating soil processes in relation to plant growth, and such also has been the

[1] *American Journal of Botany*, 16: 862.

purpose of others who have used it. However, difficulty soon arose in the application of water culture data to soil problems and in time the method became more and more a feature of plant physiology rather than that of soil science.

Plant physiology used water culture as a means for study of plant processes and, as a consequence of the technique found necessary for such studies, data showing the great productive potentiality of liquid culture media were not obtained. The fact that water culture has been known to plant physiology so long, and has not heretofore been applied in a practical way, created the necessity for a name to be given the new development. The name also would draw distinction between two uses of water culture—the strictly scientific and the economic.

Because the term "aquiculture," as used by the author in the first announcement, had previously been used in other connections, being the designation given to the culture of aquatic plants and marine animals, it becomes necessary to select a new word. "Hydroponics," which was suggested by Dr. W. A. Setchell, of the University of California, appears to convey the desired meaning better than any of a number of words considered. Hydroponics has analogy in geoponics—the Greek term by which agriculture was known for several centuries in the middle ages; this word appears to have been in common use before the latinized term "agriculture" obtained universal standing. Furthermore, "hydroponics" (*hydro,* water, and *ponos,* labor) has a strong economic and utilitarian connotation; therefore it is desirable in view of the historic use of water culture in plant physiology. The word has not been used heretofore in a scientific sense, and hence there can be no objection as to prior usage.

W. F. GERICKE

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TRANSMISSION OF THE VIRUS OF EQUINE ENCEPHALOMYELITIS BY AEDES TAENIORHYNCHUS

SINCE the initial discovery by the undersigned,[1] in 1933, that the mosquito *Aedes aegypti* is capable of transmitting the virus of equine encephalomyelitis, numerous additional transmission studies have been conducted by different investigators with various other mosquitoes. As a result some five or six additional species have been found capable of transmitting the disease.

During the latter half of the past year transmission experiments were undertaken with *Aedes taeniorhynchus.* These studies have definitely proved the ability of *Aedes taeniorhynchus* to transmit the "Western" type of equine encephalomyelitis from guinea pig to guinea pig.

In one out of a number of positive experiments a single mosquito feeding but once on a guinea pig produced the disease and death of the pig in five days. This was repeated with the same mosquito and another guinea pig, death of this pig from encephalomyelitis occurring in six days.

Transmission tests with *Aedes taeniorhynchus* and the "Eastern" type of virus, in so far as they have gone, have been negative. However, this phase of the study is incomplete and is being pursued further.

Details of the positive transmission experiments with the "Western" type of virus will be published in the near future.

R. A. KELSER

ARMY MEDICAL RESEARCH BOARD,
ANCON, CANAL ZONE

[1] R. A. Kelser, *Jour. Am. Vet. Med. Asn.,* 35: 5, May, 1933.

VITAMIN C IN PASTEURIZED MILK

SHARP[1] has recently drawn attention to the well-known effect of copper in accelerating the loss of reduced ascorbic acid in milk and has shown that this effect is smaller in milk pasteurized for 10 minutes at 77° C. than in milk pasteurized for 30 minutes at 62°–63° C.

As a result of his observation Sharp concludes that it is commercially feasible to produce copper-free pasteurized milk which will contain as much vitamin C as raw milk of the same age and that the main nutritional objection to pasteurized milk is thereby removed. The second conclusion is open to grave doubt for two reasons. First, cow's milk can not be regarded as an important source of vitamin C on account of low concentration of the vitamin in fresh milk and the uncertainty as to its preservation. Milk pasteurized in the most careful manner contains immediately after pasteurization only about 10 to 20 mg of ascorbic acid per liter. King[2] has estimated the daily human requirement at 25 mg for an infant and 40 mg for an adult, and recommends an estimated dietary allowance well above these minima. Thus an infant must take 2½ liters of the most carefully pasteurized milk in order to ensure ingestion of the mere minimum allowance of vitamin C. On the other hand, this quantity of vitamin C is contained in a relatively small volume of fruit juice.

Secondly, there are other milk constituents of which milk is the only source for infants and an important one for adults: and these may be harmed by pasteurization. For instance, pasteurization of cow's milk by the holder method renders its calcium less available for

[1] SCIENCE, 84: 461, 1936.
[2] *Physiological Reviews,* 16: 238, 1936.

the human infant[3]; and Sprawson[4] has found that raw milk protects children completely from dental caries—a most desirable result which has never been attained by the use of pasteurized milk or by any other therapeutic measures. Also, pasteurization makes cow's milk a less satisfactory food for the calf.[5]

Thus the destruction of some of the vitamin C can not be regarded as the "main nutritional objection" to pasteurizing milk. Two further points call for attention—the 2-6 dichlorophenol indophenol titration as used by Sharp for the estimation of vitamin C in milk is in our experience reliable when applied to fresh milk, but difficulties with the endpoint render it less reliable for milk samples 3 days old. And the postulated presence of an ascorbic acid oxidase in milk is difficult to reconcile with the observation that raw milk loses only about 50 per cent. of its reduced vitamin C on standing for 3 days at 2° C.

W. J. DANN
G. HOWARD SATTERFIELD

DUKE UNIVERSITY

PARAMECIUM MULTIMICRONUCLEATA VS. PARAMECIUM MULTIMICRONUCLEATUM[1]

A COMMUNICATION from Dr. C. W. Stiles informs me that it has been customary to correct grammatical errors in the naming of animals, and that this procedure is automatically authorized by the word "must" in Article 14a of the International Code. ("Specific names are (a) adjectives which must agree grammatically with the generic name.") This rule must also be observed when a species is transferred from one genus to another. Thus, when *Xiphidium attenuatum* was transferred to *Conocephalus*, it necessitated changing the specific name to *attenuatus*, though I have seen *Conocephalus attenuatum* in print.

The above rule applies only to adjectives. If the specific name is a substantive in apposition to the generic name, Article 14b applies. Here the specific name need not agree in gender with the generic name, as the example given, (*Felix leo*), shows. Consequently, the specific name need not be changed when the animal is transferred to another genus. Suppose there were a species *X-us necator,* and this were transferred to a genus with a feminine name, as *Y-a;* the masculine specific name *necator* would not have to be changed to the feminine *necatrix.*

A point of historical interest and one which may explain some of the mistakes found in both botanical and zoological literature is the following. On the basis of the rule in Latin grammar that all trees are feminine, some authors have tried to extend this principle to all plants and to use only the feminine gender for all genera in botany, and conversely, only the masculine for all genera in zoology—this on the plea that it would make it easier to distinguish between zoological and botanical genera. This custom was not accepted by the International Commission.

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GLASS GLOBES CROSS THE PACIFIC OCEAN

GLASS globes are frequently found on the beaches along the western coast of North America. They are generally regarded as net-floats, used by Japanese fishermen, which have been carried by the Japanese current to the shores of America. They are reported to come ashore most abundantly during, and following, exceptionally strong storms. These globes have been known to the local inhabitants for many years. Hundreds are collected every season and sold to the tourists for souvenirs. News items regarding these curious objects have appeared in the local press, but no reference to them has been noted in the technical literature.

During the past several years, the writer has seen many of these floats which were found along the Oregon coast. These were generally made of green bottle-glass and ranged from two to eighteen inches in diameter. The globes float about three fourths submerged and the under-water portion is covered with a growth of marine vegetation containing many small shells.

These glass balls have been found the length of the Oregon coast and as far south as the Russian River in California. Their distribution is, no doubt, much greater than is indicated here. A few years ago a former student found similar globes on the north shore of the Island of Oahu; recently others have been mentioned from the Midway Islands.[1]

It would be of interest to learn more of what is known of the migration of these floats, such as the length of time required to cross from Asia to America, and also whether those found on our shores were beached immediately upon their first crossing or have made one or more circuits before stranding.

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[3] A. L. Daniels and G. Stearns, *Jour. Biol. Chem.*, 61: 225, 1924.

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[5] A. C. McCandlish and A. N. Black, *West Scotland Agric. Coll. Res. Bull.*, No. 4, 1935.

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[1] W. B. Miller, *The National Geographic Magazine*, 70: 6, 689, 1936.

REPORTS

THE COMMISSION ON CONTINENTAL AND OCEANIC STRUCTURE OF THE INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS

I. HISTORICAL

IN 1932 the Dutch Geodetic Commission tabled a resolution advocating the appointment of a Joint Committee for the Study of the Earth's Crust for discussion by the union at its Lisbon meeting. It was resolved at Lisbon that the bureau of the union should appoint such a committee before the Edinburgh meeting in 1936. Early in 1936 the American Geophysical Union brought forward a similar, but perhaps more specific, proposition in advocating a joint discussion on "The use and value of geophysical methods in the attack upon the structural problems of oceanic and continental areas." The value of the cooperation of geologists is given special emphasis in this proposal. During the last Pacific Science Congress the same general question was also raised. On April 6, 1936, all associations were informed by the secretary of the International Union that a joint discussion would be arranged on the subject. As announced by the secretary on June 6, 1936, the president of the International Union called a "Committee on Continental and Oceanic Structure" into being, this committee to hold such scientific discussions, open to all those interested, as it considered desirable. The original committee consisted of 37 members as listed in the printed circular of June 6, 1936. R. M. Field was appointed chairman and H. Jeffreys was asked to collaborate with the president in organizing the collection and framing of the initial questions. The president of the International Union further suggested that the committee consider:

(a) The composition and personalities of a semi-permanent organization and office.
(b) The necessity for the tabulation and printing of essential data (such as the International Seismological Summary).
(c) Any other matters which require the approval and financial assistance of the General Assembly.

II. COMMITTEE MEETINGS

The meetings of the committee, at the request of the chairman, were open to all delegates to the Edinburgh Assembly. The following papers were discussed:

(1) "Recent Developments in the Geophysical Study of Oceanic Basins," by R. M. Field.
(2) "The Problems of Oceanic Structure," by H. Jeffreys.
(3) "The Importance of Submarine Topography and Geomorphology" (personal communication from D. W. Johnson), read by R. M. Field.
(4) "Recent and Additional Data Regarding the Significance of Oceanic Gravity Anomalies," by F. A. Vening Meinesz.
(5) "Terrestrial Magnetism and the Earth's Crust and Oceanic Structure," by J. A. Fleming.
(6) "Importance of Geophysical Methods, with Special Reference to Seismology," by N. H. Heck.

Recommendations as to the formation of a Commission of the International Union on Continental and Oceanic Structure were passed by the committee at its final meeting on September 21, 1936.

III. ACTION OF GENERAL ASSEMBLY ON SEPTEMBER 24, 1936

The General Assembly unanimously approved the formation of a Commission on Continental and Oceanic Structure and, with certain exceptions and amendments of the committee's original report, voted as follows:

(1) *Personnel of Commission:* G. Angenheister; R. M. Field, *chairman;* J. A. Fleming, *secretary;* B. Helland-Hansen, Harold Jeffreys, F. A. Vening Meinesz and O. T. Jones. It was the consensus of opinion that, rather than to greatly enlarge the membership of the commission, it would be wise to coopt the services of experts in the formation of subcommittees.
(2) The commission shall pay particular attention during the next three years to the structural study of oceanic basins and their margins.
(3) The supporting nations shall be urged to create similar national committees.
(4) The chairman and secretary of the commission were instructed to take steps which would insure the distribution of the proceedings of the International Union, with special reference to the organization of the commission, to the International Geological Congress, the Pan-Pacific Science Congress, National Geological Surveys, National Geographic and Geological Societies and other national organizations and agencies whose abilities and interests are related to the aims and business of the commission.

The commission will deeply appreciate advice relating to any and all matters which have to do with the development of the geophysical exploration of the great international terra incognita, the sub-oceanic lithosphere.

R. M. FIELD, *Chairman*
JNO. A. FLEMING, *Secretary*

SPECIAL ARTICLES

HE ISOLATION OF TOBACCO RING SPOT AND OTHER VIRUS PROTEINS BY ULTRACENTRIFUGATION

A HIGH molecular weight crystalline protein, which ailable evidence indicates is tobacco mosaic virus,[1] s isolated from mosaic-diseased plants by chemical thods.[2] These same methods, when applied to plants fected by some of the less stable viruses, such as those using tobacco ring spot, latent mosaic of potato, cumber mosaic and severe etch, were successful only the extent that partial purification and a limited gree of concentration were accomplished. In no innce was a crystalline protein isolated. The results, hich were probably due to the instability of these ruses, and possibly to their low concentration, indited that new methods would have to be developed in der to work successfully with such viruses. The obrvation that ultracentrifugation of the clarified juice om tobacco mosaic-diseased plants resulted in the paration of a pellet at the bottom of the tube,[3] and e demonstration by means of x-ray analysis[4] and rus activity measurements[5] that this pellet consisted crystalline tobacco mosaic virus protein suggested e new methods that have been employed. If other ruses are high molecular weight proteins, it should be ssible to concentrate and isolate them by ultrantrifugation.

This possibility was explored by ultracentrifuging e juice from leaves of Turkish tobacco plants dised with tobacco ring spot virus, in 7 to 17 cc celluid tubes, for about 3 hours in a maximum field of out 60,000 times gravity. Ring spot virus is unble and becomes almost completely inactivated on erely standing at room temperature for one day,[6] nce it was necessary to keep the preparations cold ring the entire manipulation. This was accomshed by working with the material in a room held about 2° C. and by carrying out the ultracentrifution in a quantity head[7] precooled to about 0° C. nce the centrifuge head spins in a vacuum, it absorbs t little heat, and during a 3-hour run usually warms less than 5°. On ultracentrifugation of tobacco ng spot juice, which had been previously clarified by low-speed centrifugation in a Swedish angle centrifuge or by filtration through filter paper, very small pellets, less than 1/50th the size customarily found with tobacco mosaic juice, were obtained. Although about 80 per cent. of the amount of protein originally in the juice was found in the supernatant liquid, this protein was inactive and all the virus activity was concentrated in the pellets. Thus one ultracentrifugation served to separate the virus activity from the major portion of the protein. Since these pellets were so small and were found to contain much pigment and colloidal matter, several were combined, well suspended in 0.1 M phosphate buffer at pH 7 and spun on a Swedish angle centrifuge for 15 minutes. This served to further purify the protein, for much of the pigment and colloidal matter sedimented to the bottom of the tube. The supernatant liquid, which contained the soluble protein and a small amount of finely dispersed colloidal matter, was then ultracentrifuged and the whole process of alternate ultracentrifugation, re-solution of the protein and low-speed angle centrifugation was repeated 2 times. Each ultracentrifugation served to separate the high molecular weight from the low molecular weight material and to aggregate colloidal matter, and each low speed angle centrifugation separated this aggregated colloidal matter from the soluble material.

No protein could be demonstrated in the supernatant liquid from the third ultracentrifugation. The pellet which was obtained was found to contain but a trace of insoluble matter and to consist of crystalline protein. In the analytical ultracentrifuge a solution of this protein gave a sharp boundary characteristic of a single molecular species with sedimentation constant $S_{20^\circ} = \text{ca } 115 \times 10^{-13}$ cm. sec.$^{-1}$ dynes^{-1}. A total of about 10 mg of this high molecular weight protein has been prepared on 4 different occasions and the yield has varied from about 0.005 to 0.01 mg of protein per gram of starting material. This indicates that diseased plants contain about one part of this protein per 100,000 parts of plant material and hence that the virus activity of the protein concentrate might be expected to approach about 100,000 times that of the starting material. The virus activity of the protein has been tested on 10 different occasions and in every instance solutions containing but 10^{-7} grams of the protein per cc were found to be active and capable of causing necrotic lesions on cowpea,[8] *Vigna sinensis* Endl. Since the juice from plants diseased with tobacco ring spot virus, when similarly tested, was not found to be

[1] W. M. Stanley, *Amer. Jour. Bot.*, 24: No. 2, 1937.

[2] W. M. Stanley, SCIENCE, 81: 644, 1935; *Phytopath.*, 26: 305, 1936; *Jour. Biol. Chem.*, 115: 673, 1936.

[3] R. W. G. Wyckoff, J. Biscoe and W. M. Stanley, *Jour. Biol. Chem.*, 117: 57, 1937.

[4] R. W. G. Wyckoff and R. B. Corey, SCIENCE, 84: 513, 1936.

[5] W. M. Stanley, *Jour. Biol. Chem.*, 117: 755, 1937.

[6] C. N. Priode, *Amer. Jour. Bot.*, 15: 88, 1928.

[7] R. W. G. Wyckoff and J. B. Lagsdin, *Rev. Sci. Instr.*, 8: no. 3, 1937.

[8] W. C. Price, *Contrib. Boyce Thompson Inst.*, 4: 359, 1932.

active at dilutions greater than 1 to 1,000, the protein isolated by the ultracentrifugal method is about 10,000 times more active than the starting material. This tremendous concentration of virus activity and the very small yield of protein are in striking contrast to the results obtained in the case of mosaic-diseased Turkish tobacco plants, which were found to contain about one part per 500 of crystallizable tobacco mosaic virus protein, the activity of which was, therefore, only about 500 times that of the starting material.

As indicated by the great difference in sedimentation constants, the properties of tobacco ring spot virus protein are quite different from those of tobacco mosaic virus protein. The latter does not become denatured and loses practically no virus activity on short exposures to hydrogen ion concentrations between pH 2 and 3 or to temperatures up to about 70° C. It does not denature and its activity is not lost on standing for several days at room temperature. In marked contrast, tobacco ring spot virus protein is almost completely denatured and inactivated after one hour at pH 3, is completely denatured and inactivated after a 5-minute exposure to a temperature of 64° C., and is partially inactivated after one day and almost completely inactivated after 6 days at room temperature. Of interest is the fact that it may be more stable than tobacco mosaic virus protein towards alkali, for ring spot virus protein loses only a small amount of activity on standing for one hour at pH 9.6. It is, however, completely denatured and inactivated after standing for one hour at pH 10.8.

The serological properties of the 2 proteins are also quite different for, although the sera of animals injected with tobacco mosaic virus protein give a precipitate when mixed with solutions containing only 10^{-6} gm of mosaic protein per cc, they fail to give a precipitate when mixed with solutions containing as much as 10^{-3} gm of tobacco ring spot virus protein per cc. This property was put to practical use in the purification of one sample of ring spot virus containing a trace of tobacco mosaic virus protein as a contaminant. Antiserum to mosaic virus protein was added to the contaminated preparation, the precipitated mosaic virus protein was removed by low-speed angle centrifugation, and the ring spot protein was then separated from the excess antiserum by ultracentrifugation. It was thus possible to separate and remove mosaic protein from ring spot protein. These results demonstrate, as might have been expected from work with the crude juices,[9] that the mosaic and ring spot proteins are distinct serological entities. Further evidence indicating that the two proteins are different is found in the fact that the x-ray diffraction pattern of crystalline ring spot virus protein differs from that of crystalline tobacco mosaic virus protein. It has been possible, therefore, by a method involving use of the newly developed quantity ultracentrifuge, to isolate from Turkish tobacco plants diseased with ring spot virus a high molecular weight protein possessing the properties of ring spot virus and differing markedly from tobacco mosaic virus protein in its concentration in the plant and in its physical, chemical and serological properties.

This method has also been used in examining the juices of Turkish tobacco plants diseased with latent mosaic of potato (X-virus), severe etch and cucumber mosaic viruses, respectively. In the case of latent mosaic virus the pellets which were obtained were about 1/20th to 1/50th the size customarily obtained with mosaic juice and were found to contain all the virus activity. The protein in these pellets was also of a single molecular species with a sedimentation constant, S_{20} = ca 110, close to that of the ring spot virus protein. With severe etch virus the pellets were larger than those of latent mosaic virus and were also found to contain all the virus activity. The protein in these pellets sedimented more diffusely than did the ring spot and latent mosaic virus proteins, but the heterogeneity this indicates was probably the result of decomposition that occurred before the ultracentrifugal analysis was carried out. Although the boundaries obtained were too diffuse for accurate measurement, it was obvious that severe etch virus protein sediments at a rate comparable with that of the tobacco mosaic virus protein. When the juice from cucumber mosaic-diseased plants was ultracentrifuged, insufficient soluble protein for physical and chemical tests was obtained, despite the fact that all the virus activity was concentrated at the bottoms of the tubes. If, as seems to be the case, the dilution end-points of viruses may be used as a rough criterion of the amount of virus protein present in the host, then, since the dilution end-point of juice from cucumber mosaic-diseased plants is about 1 to 100, the amount of virus protein would be expected to be about 0.001 mg or less per gram of plant material. It would be necessary, therefore, to ultracentrifuge a liter or more of juice in order to secure a milligram of virus protein. Attempts to concentrate the juice before ultracentrifugation by means of precipitation with ammonium sulfate and solution in from 1/5th to 1/15th the original volume, although quite successful and useful in the cases of ring spot and latent mosaic viruses, were not successful in the case of cucumber mosaic virus, possibly because of its extreme instability.

The tremendous difference in the concentration of the various virus proteins in well-diseased Turkish tobacco plants is especially noteworthy. The concentration in the host ranges from one part per 500 for tobacco mosaic virus protein, through latent mosaic and severe etch to ring spot virus protein which occurs

[9] K. S. Chester, *Phytopath.*, 25: 686, 1935.

in about one part per 100,000, and to cucumber mosaic virus protein which possibly may occur in less than a part per million. It seems likely that, with respect to concentration in the host and to instability, certain of these viruses are much more nearly comparable to many animal viruses than is the very stable and abundant tobacco mosaic virus. As a whole, the results demonstrate that high molecular weight proteins are characteristic of these various virus diseases, and that the physical, chemical and serological properties and the concentration in the host of these proteins differ widely.

Summary

A high molecular weight crystalline protein, possessing the properties of ring spot virus and differing markedly from tobacco mosaic virus protein in its physical, chemical and serological properties, has been isolated by means of an ultracentrifuge from Turkish tobacco plants diseased with tobacco ring spot virus. Ultracentrifugal methods were also used to demonstrate that high molecular weight proteins are characteristic of other virus diseases. The concentration of the different virus proteins in the host was found to differ greatly. The quantity ultracentrifuge, used in conjunction with an analytical ultracentrifuge, has proven to be a powerful tool for the concentration, purification and crystallization of high molecular weight virus proteins and to be indispensable in the case of unstable viruses existing in low concentration in the host.

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VITAMIN B_1 A GROWTH FACTOR FOR HIGHER PLANTS

In experiments to be reported in detail elsewhere, we have found that vitamin B_1 is an important "growth factor" or "growth hormone" for growth *in vitro* of isolated roots. It seems probable that vitamin B_1 is the active principle of yeast extract, shown by Robbins[1] to be beneficial for the growth of isolated corn roots, and by White[2] to be necessary for the continued growth of isolated tomato roots.

After an extensive search for optimal conditions and optimal composition of the nutrient solution it was first found possible to grow freshly isolated pea roots in a pure synthetic medium containing inorganic salts and sucrose. Additions of yeast extract had no stimulating effect upon this initial culture or "passage" and, in fact, yeast extract concentrations higher than 0.01 per cent. were slightly inhibitory, due probably to heteroauxin present in the yeast. If such roots were subcultured by the removal of 10 mm tips into fresh medium and particularly if this procedure were repeated several times, yeast extract was, however, found to be essential for growth. Thus in the third passage pea roots, cultivated in nutrient medium but without yeast, ceased growth completely, whereas roots in the same medium but with the addition of 0.01 per cent. yeast extract may be carried through many passages with an average growth rate of 6 to 9 mm per root per day. The pea root as cut from the seedling plant contains thus sufficient "growth factor" to permit of growth for some time and the initial culture is not influenced by yeast extract, since this growth factor is not limiting. After two or more passages this initial supply is, however, used up and the root responds to growth factor present in the yeast.

It was next found that vitamin B concentrates are considerably more active as a source of the root growth factor than is yeast. This suggested that vitamin B_1 itself might be the active principle and experiments carried out with Merck's crystalline preparation have shown that this is the case. Table I shows that 0.2 gamma per cc is able to replace the optimal yeast extract concentration completely and is in fact superior to it.

TABLE I
GROWTH RATE OF EXCISED PEA ROOTS IN MM PER ROOT PER PASSAGE

Passage	I	II	III	IV	V
No addition	65	10	0	0	0
0.01 per cent. Yeast ext.	64	43	45	40	55
Cryst. B_1 0.2 γ/cc	65	72	65	66	65

Much smaller concentrations of crystalline vitamin B_1 than 0.2 gamma per cc suffice. Thus 0.002 gamma per cc still has a marked stimulating effect upon the growth of these roots. Two gamma per cc has on the other hand no more effect than does 0.2 gamma per cc.

We have as yet no indication that substances other than vitamin B_1 (for example, amino acids in small amounts[3]) are necessary as "growth substances" for pea roots. It is possible, however, that over larger numbers of passages such co-growth substances may be indispensable.

Vitamin B_1 is then not only an animal vitamin and a growth substance for fungi and bacteria, but it is also a growth substance for higher plants. Kögl and Haagen-Smit[4] in a paper published while the above

[1] W. J. Robbins, *Bot. Gaz.*, 74, 59, 1922.
[2] P. R. White, *Plant Physiol.*, 9, 585, 1934.

[3] P. R. White. Paper read at the annual meeting of the Amer. Soc. of Plant Physiologists, Atlantic City, December, 1936.
[4] F. Kögl and A. Haagen-Smit, *Zeit. Physiol. Chemie*, 243, 209, 1936.

experiments with crystalline vitamin B_1 were in progress confirm this conclusion, in that they have shown that B_1 is beneficial to the growth *in vitro* of excised pea embryos, the effect being apparently principally upon the root.

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THE SPARING EFFECT OF DOG DISTEMPER ON EXPERIMENTAL POLIOMYELITIS[1]

We wish to report a disease produced in rhesus monkeys by the virus of dog distemper and the sparing effect it has on subsequently induced poliomyelitis.

Distemper virus from ferret spleen was inoculated into rhesus monkeys intracerebrally, subcutaneously and intraperitoneally as well as by combinations of these methods. From 0.2 to 0.5 cc of the supernatant fluid of a 20 per cent. emulsion of splenic tissue was used. Twenty-eight monkeys have been infected in this fashion and all have contracted a characteristic and uniform disease which strikingly resembles distemper. The incubation has been from 3 to 9 days, the febrile reaction has lasted about three weeks and rhinitis, conjunctivitis, red streaks about the eyes, weakness and slight incoordination have been the usual symptoms. Only one of the animals died of distemper. This monkey developed encephalitis and expired several weeks after inoculation. Two other animals were successfully infected from an emulsion of his brain and the disease has also been passed from monkey to monkey by injection of infected blood.

Twenty-five of the monkeys suffering from distemper were later given poliomyelitis (0.2 cc of the supernatant fluid of a 10 per cent. cord emulsion). This virus has regularly produced poliomyelitis in our laboratory with a mortality of 100 per cent. However, in the animals suffering from distemper the results were entirely different. The mortality rate was only 33 per cent. and an equal number recovered without residual paralysis. The animals which did die differed from the controls in that paralysis was delayed.

The results are interesting in that they show the protective power of a relatively benign disease on one otherwise invariably fatal, in the degree to which protection has been afforded monkeys against poliomyelitis and because they suggest the existence of a new immunity mechanism in the virus field.

TABLE I

Effect of Distemper on Course and Outcome of Poliomyelitis in Rhesus Monkeys

Group	Animal number	Days after distemper inoculation poliomyelitis was given	Incubation of poliomyelitis in days to paralysis	Outcome		Number of extremities paralyzed	
				Recovered	Died		
III	56	4	no paralysis	×		0	
	58	4	13	×		1	
	60	4	13		×	all	
	62	4	13	×		2	
Control	31		7		×	all	
I	42	7	13	×		2	
	43	7	13	×		3	
	38	7	no paralysis	×		0	
	48	7	12		×	3	Polio death on 24th day
Control	49		8		×	all	
IV	57	9	no paralysis	×		0	
	59	9	no paralysis		×	0	Lobar pneumonia 16th day
	61	9	no paralysis	×		0	
	63	9	12		×	4	
Control	74		8		×	all	
V	64	13	15	×		2	
	66	13	no paralysis	×		0	
	68	13	7		×	all	Polio death 7th day
	70	13	no paralysis	×		0	
Control	75		7		×	all	
VI	65	20	11		×	all	Polio death on 11th day
	69	20	12	×		2	
VII	37	70–20	13	×		4	
	39	70–20	8		×	all	
	44	70–20	9	×		4	
Control	53		8		×	all	
II	36	31	6		×	all	Group indistinguishable from control animals
	40	31	6		×	all	
	46	31	6		×	all	
	47	31	6		×	all	
Control	51		5		×	all	

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Margaret Douglass

H. E. Robinson

[1] From the laboratories of Grasslands Hospital, Valhalla, New York.

SCIENTIFIC APPARATUS AND LABORATORY METHODS

THE ELECTRICALLY DRIVEN ULTRACENTRIFUGE

THE air-driven "vacuum" type of ultracentrifuge originally developed in this laboratory[1] has already found sufficient application in the different sciences[2, 3, 4] to warrant an examination of certain possible variations and improvements. Briefly, in the "vacuum" type of air-driven ultracentrifuge the large rotor (centrifuge) is both supported and spun inside a vacuum tight chamber by a small flexible shaft or tube which extends out of the vacuum chamber through an oil gland. The rotating parts consist of the large rotor (centrifuge) inside the vacuum chamber, a much smaller turbine above the vacuum chamber, which is both supported and spun by air, and the flexible shaft that connects the turbine to the centrifuge through the vacuum tight oil gland and lies in their vertical axis of rotation. Although the amount of air required to drive the air turbine is not large (2 to 3 cu. ft. per min., 15 to 20 lbs/in^2 gauge pressure in our latest design), the amount of air required to support the rotating parts is in comparison almost negligible and need only be supplied at from 5 to 15 lbs/in^2 gauge pressure. In many laboratories air compressors of sufficient capacity are not available, so that, in order to run the air-driven centrifuge, an auxiliary compressor must be installed. However, if it were possible to spin the turbine by some other means, the amount of air required to support the rotating parts could then be supplied by a small "blower" or compressor, which is available commercially at the cost of only a few dollars. In view of this and other reasons that will be given later, a study of the available ways of both supporting and driving the turbine has been undertaken, and the present note gives some of our results with an electrical type of drive.

Fig. 1 shows a schematic diagram of the type of apparatus used. A is the large rotor or centrifuge which is surrounded by the vacuum tight chamber V. S is the flexible shaft (1/16 in. rod or tube in the apparatus used), and T is the driving rotor. The vacuum tight gland or bearing G is mounted in round Duprene rings R and vacuum pump oil is forced into the hollow space between the two bushings B. The bushings are usually made of brass, bronze, babbit metal, etc., depending upon the material of the small shaft. Their construction has been previously described. The driving rotor T is supported on an air cushion between the bakelite collar C and T. Many

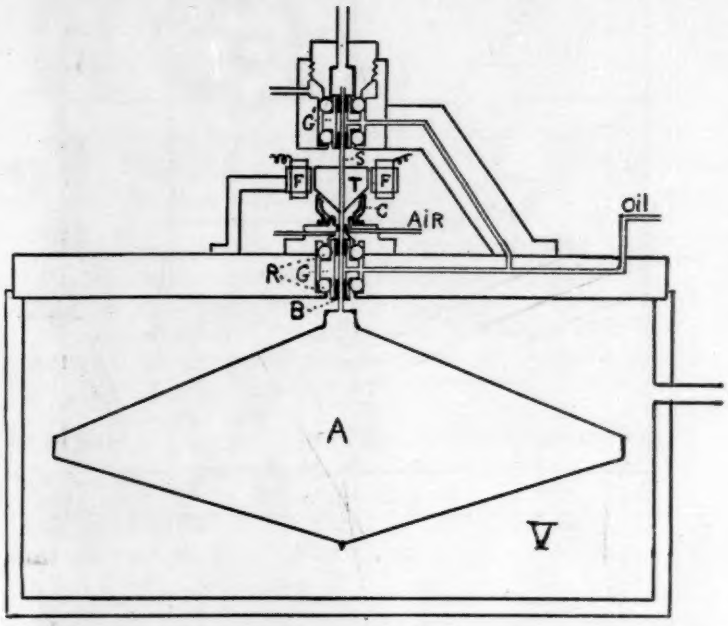

Fig. 1

variations in this air cushion support may be used[1] which are satisfactory. The upper bearing or gland G[1] is made similar to G so that when a tubular shaft S is used the rotor A itself may be evacuated. The driving rotor T is the familiar squirrel cage type of armature so that an alternating current in the field coils F causes it to spin. The principle of the induction motor is thus used to spin T, while a small amount of air at a pressure of a few lbs/in^2 is used to support it. The advantage of this type of electrical drive is that, if properly constructed, the centrifuge will start from rest and gradually accelerate until a rotational frequency is attained practically equal to that of the alternating current in the field coils F. The fact that in practice the rotor T reaches this speed results from the almost negligible friction except for that of the air on the small rotor itself. It is possible to construct electrical circuits and field coil magnets to give fields of considerable magnitude at the desired frequency so that the maximum rotational speed is set by the breaking strength of T or the centrifuge A. In most biological, chemical or medical experiments A is 8 to 10 inches in diameter and usually will explode if driven much above 1000 r.p.s. Hence in practice it is not difficult to construct T to stand this speed.

The A. C. supply for the motor was obtained from the inverter shown in Fig. 2. This is known as the double capacity single phase polycyclic type of inverter. For a detailed description of its characteristics and its mode of operation a paper by Sabbah[5] should be consulted.

The circuit was constructed from transformers, capacities, etc., which can usually be found in any

[1] Beams and Pickels, *Rev. Sci. Inst.*, 6: 299, 1935.
[2] Bauer and Pickels, *Jour. Exp. Med.*, 64: 503, 1936.
[3] Wyckoff and Corey, SCIENCE, 84: 513, 1936.
[4] Beams and Haynes, *Phys. Rev.*, 49: 644, 1936.

[5] C. A. Sabbah, *G. E. Review*, 34: 288, 1931.

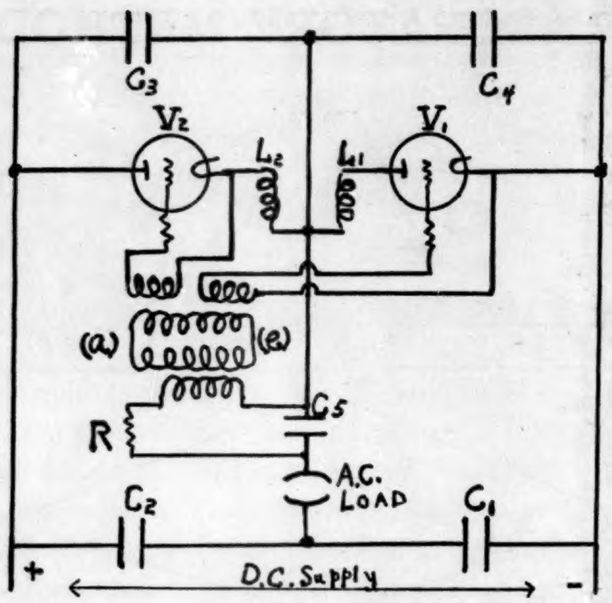

Fig. 2

laboratory or obtained at small cost. For the reactors L_1 and L_2 two windings of a one to one insulating transformer were used. Thyratrons FG-67 were used for V_1 and V_2. The grid excitation was obtained as shown. The frequency of the circuit could be changed by an alteration of R or by a change in any of the capacities C_1 to C_5. The circuit has good stability at any frequency under that at which the tubes V_1 and V_2 fail. This upper limit is well above 1,000 cycles with these thyratrons.

At times the circuit fails to start when the D. C. supply (about 250 volts) is connected. It may be started without producing failure by connecting the 60 cycle lighting supply through a resistance to the points (a) and (b). It is well to protect the tubes in case of failure by a fast circuit breaker or fuse of suitable capacity in the D. C. line.

This type of circuit is capable of furnishing considerable power at frequencies which can be changed gradually or abruptly by a variation in circuit constants. This is of advantage in the initial acceleration of the centrifuge as the frequency may be set initially at some low value and increased as the centrifuge speeds up.

Our experience shows that the induction motor type of drive gives a speed practically as constant as the frequency of the circuit and therefore better than usually required in most work. The heating of the rotor T gives no fundamental trouble because where accurate temperature control is required it is standard practice to maintain the vacuum chamber V at constant temperature by the usual thermostatic controls. If the air surrounding the rotor T is troublesome, T can easily be sealed in a vacuum chamber by a change in design. It should be pointed out that several other types of electrical circuits and drives may be used besides that described above. The synchronous motor drive has been used in this laboratory by Davis[6] to produce 1,400 r.p.s., while methods of driving high speed electrical motors have also been devised, especially by Colwell and Hall.[7]

Although at present the air turbine drive must be used to obtain the very highest rotational speeds, the electrical drive serves equally well for many purposes and has the advantage, after once being set up, that it is automatic and requires no attention from the operator to keep the speed constant. This work will be continued, and we hope that a more detailed description can be published later.

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6 T. Davis, *Rev. Sci. Inst.*, 7: 96, 1936.
7 Colwell and Hall, *Jour. Franklin Inst.*, 221: 797, 1936.

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